Real-time Dynamic Model Reduction and Calibration for Electric Power Systems

ASCR Project: Real-time Model Validation and Calibration for Large Interconnected Time-variant Systems Using Online Measurement Data

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Abstract

The interconnected electric power systems are coordinately managed by different utility companies. Presently, each company performs simulation studies using offline dynamic models of the entire interconnection to guide its real-time operations. This approach has been challenged by the following trends in power systems: more dynamic market activities, increasing variable renewable resources, and emerging demand response schemes. These changes drive the system to deviate from status assumed in offline models. Models faithfully representing the dynamic behaviors of the interconnection are needed to study its impact on each utility's own system in order to maintain reliable and efficient operations of the entire system.

Challenges with modeling a complex system, such as the power grid, exist in two aspects: 1) high complexity caused by the large number of elements and the way they interact, and 2) high uncertainty caused by continually-changing operating environment, system configurations, and human involvements. This research proposes the following procedure to solve the above difficulties in modeling inteconnnected power systems, for the purpose of real-time operations and control: 1) use a hierarchical structure and reduced-order models to represent the entire system, as illustrated in Fig. 1. The internal system is operated by a utility company while the external system represents the rest of the interconnection. The latter is reduced to several lower order systems, and the degree of reduction of any particular part of the external system depends on its impact on the internal system, determined by a sensitivity study; 2) use online measurement data to calibrate the parameters of the reduced model in real time, as shown in Fig. 2. A set of model parameters is selected for calibration, again based on their influence on system performance. Particle filter method is used in this step to deal with the nonlinearity of power system models; 3) quantify the uncertainty with the simulation results from calibrated reduced-order models to determine the margin for operation limits. These techniques will be applied to generate and calibrate the reduced models of conventional generators, wind and solar power plants and loads. Continual model calibration will be performed to keep model parameters current, capable of predicting emergent behaviors, and faithfully revealing consequences of desired or undesired stimulus to the system.

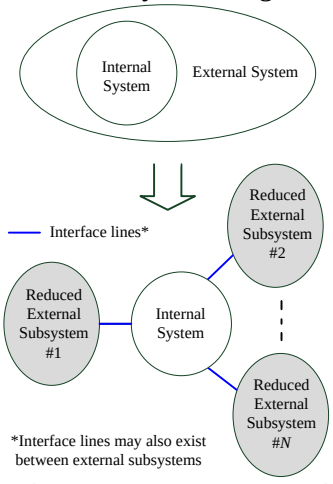

Fig. 1. Modeling of an interconnected power system for real-time study

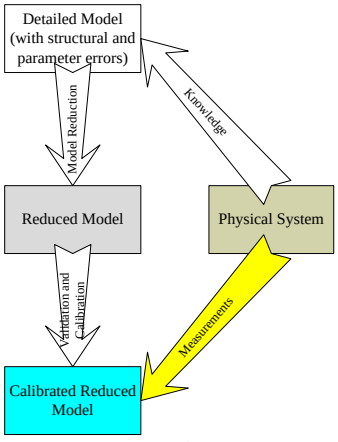

Fig. 2. Process to calibrate reduced models for external power systems